A STUDY ON THE INFLUENCES OF ENVIRONMENTAL FACTORS TO THE PURE LINE SELECTION FROM HYBRID POPULATION OF RICE*

Part 1. The Response of Yielding Capacity Among Different Pure Line Groups Selected at Different Localities

by

T. S. MIU**

INTRODUCTION

In this study, the following two hybrid combinations were used:

(A) Chia-nung 242×Baritol

(B) Taichung 65×Baritol

in which, parent varieties "Chia-nung 242" and "Taichung 65" are the most popular rice varieties in Taiwan. "Baritol" is an upland rice variety cultivated in the aboriginal region of Taiwan.

By the use of two crossing combinations mentioned above, it is expected that through the successional generation of selections in the breeding program, new rice varieties with disease and drought resistant characters might be developed. How environmental factors influence the chance of pure-line selection from the hybrid populations having the same parental combinations was also involved in the study. F_2 individuals in each of the populations were divided into 4 equal portions and sent to 4 localities situated at from the north to the south of the Province, for segregation and natural selection under the different natural conditions in order to obtain data and references for the readjustment of rice breeding regions according to natural environs.

MATERIALS AND METHODS

After the F_2 generation in 1960, seeds of each of the two hybrid combinations were thoroughly mixed, they were divided into 4 equal portions for planting at 4 different localities, namely, Taipei, Taichung, Chiayi and Pintung. From agricultural point of view, these 4 localities represent 4 marked rice regions in Taiwan. At each of these 4 localities two crops of rice in a year are grown. Each of the two crops was applied with standard levels of fertilizer, or at a rate of 80N, 40 P_2O_5, 40 K_2O kg/ha. Seeds obtained from each combination at different localities were kept in separate. But seeds of each combination at each locality were thoroughly mixed and a portion of which taken at random was used for planting of next crops. This was continued until F_6 generation. Thereafter, selections for better individuals from each of the population were made and tested for their breeding-trueness by means of

* This topic is a part of the author's research work on "The Causes of Low Yield of Rice in Tropical and Subtropical Regions" which is subsidized by Rockefeller Foundation in the rice breeding program.

** Senior Agronomist, Taiwan Agricultural Research Institute.

headrows. In comparative experiments of these lines, most of the poorer lines were discarded. The agronomic characters of the selected lines were also compared, 12 desirable lines from each locality, having 6 lines from combination (A) and 6 lines from combination (B) were collected. Thus there were 48 lines in total from the 4 localities (12×4). A regional test of these lines was then conducted at the four localities. Their adaptation to the localities in relation with the source of the group of rice variety is then traced.

The selected rice lines or varieties for the regional test are shown in the following:

Combination / Breeding Station	Combination A Chia-nung 242×Baritol			Combination B Taichung 65×Baritol		
Taipei	Taipei No. 1	Taipei No. 2	Taipei No. 3	Taipei No. 7	Taipei No. 8	Taipei No. 9
	Taipei No. 4	Taipei No. 5	Taipei No. 6	Taipei No. 10	Taipei No. 11	Taipei No. 12
Taichung	Taichung No. 1	Taichung No. 2	Taichung No. 3	Taichung No. 7	Taichung No. 8	Taichung No. 9
	Taichung No. 4	Taichung No. 5	Taichung No. 6	Taichung No. 10	Taichung No. 11	Taichung No. 12
Chiayi	Chiayi No. 1	Chiayi No. 2	Chiayi No. 3	Chiayi No. 7	Chiayi No. 8	Chiayi No. 9
	Chiayi No. 4	Chiayi No. 5	Chiayi No. 6	Chiayi No. 10	Chiayi No. 11	Chiayi No. 12
Pintung	Pintung No. 1	Pintung No. 2	Pintung No. 3	Pintung No. 7	Pintung No. 8	Pintung No. 9
	Pintung No. 4	Pintung No. 5	Pintung No. 6	Pintung No. 10	Pintung No. 11	Pintung No. 12

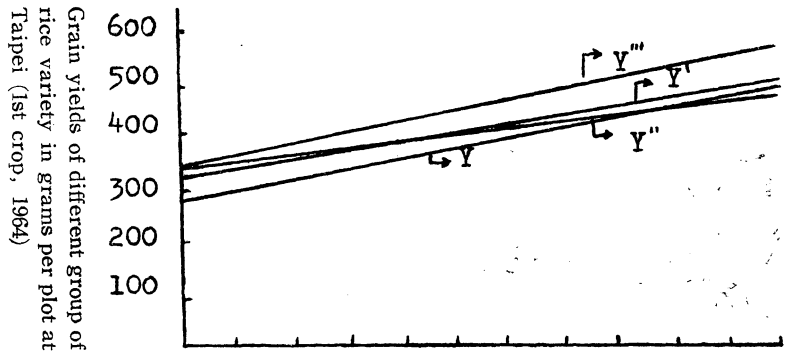
The varieties shown above were included in the regional test using random blocks were carried out at Taipei, Taichung, Chiayi & Pintung. Each of the experiments had 2 replications in the test during the first crop of 1964, and 6 replications the second crop of 1964, in order to make the results of this experiment more reliable.

EXPERIMENTAL RESULTS AND DISCUSSION

From Fig. 1 (Page 3), when we compared the grain yield, it was found that among 4 variety groups, the lines selected at Pintung were the highest yielder in Taipei during 1st crop. But its heading time was 3.31 days, in average, later than those lines selected at Taipei. While the yields of Taichung varieties was the next higher than the lines selected at Taipei and their heading time was 1.25 days later than those selected at Taipei. Lines from Chiayi yielded only little higher than those selected at Taipei, but their heading time was 3.43 days later.

The grain yields of 4 variety groups shown by trend line are as follows:

$Y = 283.06 + 18.08\,x$ (Taipei varieties)
$Y' = 328.55 + 15.87\,x$ (Taichung varieties)
$Y'' = 335.90 + 12.64\,x$ (Chiayi varieties)
$Y''' = 347.31 + 19.58\,x$ (Pintung varieties)

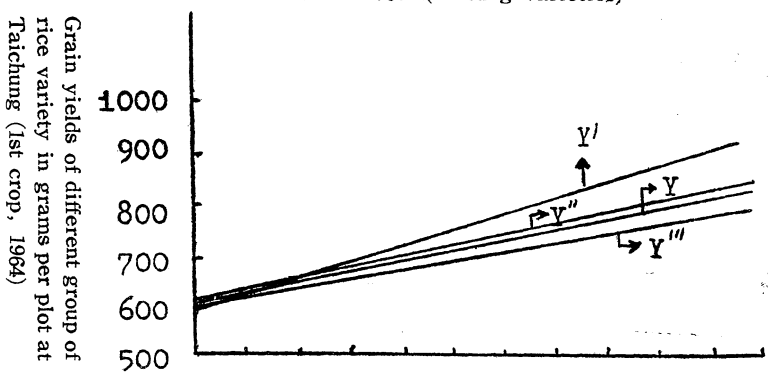


Each scale represents the position of each variety (pure line) arranged by order of yielding ability.

Fig. 1: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Taipei, 1st crop, 1964.

According to the adaptability of the 4 variety groups in Taipei, it may be seen that the varieties developed from the southern regions of the Province is always higher in yielding capacity than those bred in Taipei when they were grown during first crop. In other words, there seems to be that Taipei is not a most suitable place for rice breeding of the Province, because that the new lines of this experiment selected from central and southern Taiwan appeared to be having acquired more yielding potential as tested during 1st crop in Taipei. However, varieties selected from Pintung and Chiayi were 3 days more later in heading time then these selected

$Y = 605.14 + 20.96\,x$ (Taipei varieties)
$Y' = 602.83 + 31.15\,x$ (Taichung varieties)
$Y'' = 618.29 + 21.22\,x$ (Chiayi varieties)
$Y''' = 601.12 + 17.60\,x$ (Pintung varieties)



Each scale represents the position of each variety (pure line) arranged by order of yielding ability.

Fig. 2: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Taichung, 1st crop, 1964.

in Taipei, from the crop rotation point of view, it is better to use varieties from Taichung which is comparatively earlier in maturity in Taipei.

Taichung is located at central part of Taiwan, and where the soil fertility is more rich than the other regions. Under such a condition, lines selected from Taichung & cultivated in Taichung gave the highest yield. The slope of trend line of yielding capacity rises steeply after 1–2 grade on X coordinate. It shows that Taichung is a more ideal place for rice breeding for the 1st crop.

In comparison with the yielding capacity of four rice groups (Fig 2), Taichung varieties yields highest in place where they originated (Taichung). Where as Chiayi varieties ranked next; Taipei varieties the third. and Pintung varieties the last in yielding capacity.

It is quite evident that there is a tendency for the yielding capacity of different rice groups in Taichung to decrease with the increase in distance between the breeding station and the Taichung region.

As for the heading period among the 4 variety groups in Taichung, lines selected in Taipei were earlier than the other 3 groups, the average number of days from sowing to heading is 131.54, But Taichung varieties were 1.33 days average later than the Taipei lines, and Chiayi varieties 3.67 days more, and Pintung varieties, 2.71 days more than Taipei varieties, on average.

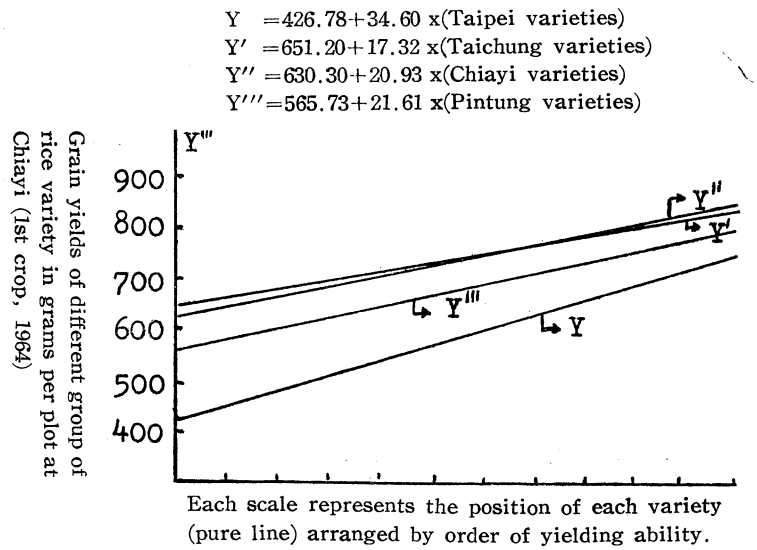


Fig. 3: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Chiayi, 1st crop, 1964.

From Fig. 3, the results in Chiayi were discussed. In first crop of the year, we had a serious drought there, so the irrigating water was not sufficient. The yielding capacity of Taichung and Chiayi variety groups was somewhat close with each other as shown on the trend lines Y′ and Y″. The two lines crosses each other on the middle point but the opposit vertical angle is very acute which supposes that a part of the two groups of varieties may be replaced each other in practical cultivation.

The grain yields of Pintung varieties were lower than Chiayi and Taichung varieties in Chiayi, and the Taipei varieties in Chiayi due to drought weather condition and serious pest damages (rice-blast and moth-borers were the more important) showed the lowest yields.

The water levels under ground are higher both in Taipei and Pintung, so varieties bred in such a condition, naturally can not tolerate drought.

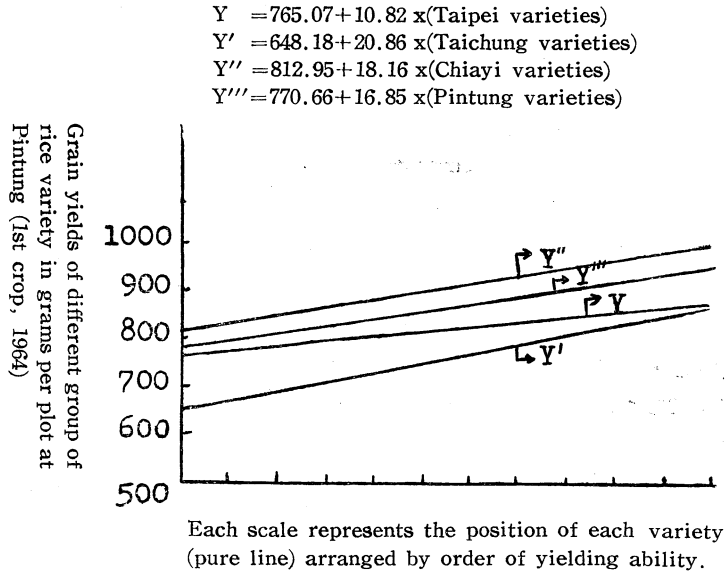


Fig. 4: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Pintung, 1st crop, 1964.

In Pintung (see Fig 4), the grain yields of Chiayi varieties were the highest among the 4 lines. But the yield trend line of Pintung varieties is little lower than the line of Chiayi varieties though the latter is very closely parallel to it. As for trend lines of Taipei & Taichung varieties, they are much lower than the former two lines. It indicated that rice varieties developed from Taipei and Taichung cannot adapte to Pintung environment during the period of the 1st crop of rice. But Taipei varieties in Pintung yielded higher than Taichung varieties when we compare the grain yields of the two groups. We found that it may be caused by under-ground water levels. In Pintung the water level under the paddy field is usually higher which is somewhat similar to the condition of rice field in Taipei.

Then we conclude the first crop experiments. Although the soil fertilities of this experiment at 4 localities were not on a homogeneous level, but when we compared the yielding capacities among the 4 groups of varieties cultivated at single place, it may find out that in rice cross-breeding program in this Province, varieties developed from southern part of this Island may be adapted to north-ward areas, but conversely, the northern varieties are always not adapted to south-ward parts. (compare the trend line)

During the 1st crop, Taichung varieties may be adapted to the southern area until Chiayi region is reached or to the north, Taipei. But when they were introduced to Pintung area, the most southern part of the Island, the grain yields were not so good.

Because Taicheng is located at central Taiwan, it seems to be a most suitable place for rice-breeding. According to the regional test of the 1st crop in Taichung (see Fig. 2) the rice varieties developed from Taichuug yields highest than all the other variety groups developed from other regions. It may be concluded that, there exists a relationshjp between the geographic distance from Taichung and yielding capacity of rice group cultivated in Taichung. In order words, the near the station located to Taichung, the higher the variety yields. This phenomenon shows Taichung is a most suitable place for rice breeding during the 1st crop period of Taiwan.

Any variety group of this experiment introduced to Taichung may always get a suitable return of grain yields, and the variability of grain yield among the 4 rice groups cultivated in Taichung gives the smallest magnitude in distribution of yielding ability. This also indicate that Taichung is the most favorable region for breeding rice varieties for this Province.

From Fig. 3, we can see that in Chiayi, the two fitting lines of Chiayi and Taichung varieties respectively are crossing each other near the middle point, and the vertical angle formed by the two lines is rather acute. So we may suppose that some of the Taichung varieties may be adapted to Chiayi during 1st crop period. But it seems that varieties from Pintung are not so adaptable to Chiayi according to the position of Pintung's line in Fig. 3. While the Taipei varieties are the lowest yielder in Chiayi. Because of the higher yields of Chiayi varieties in Chiayi, so we say that Chiayi is also a suitable place for breeding rice varieties during 1st crop.

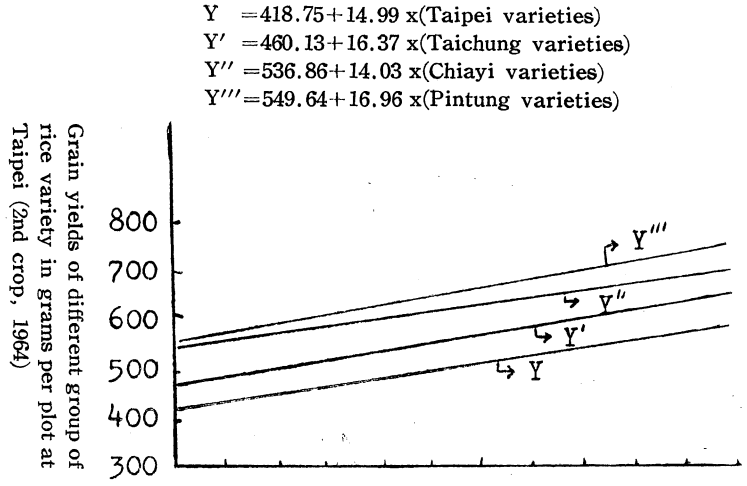


Fig. 5: Trend lines of yielding capacity of 4 rice-variety groups bred at different localities cultivated in Taipei (2nd crop, 1964)

In Fig. 4, it shows that Chaiyi varieties may be well adapted to Pintung and even better than those Pintung local bred lines.

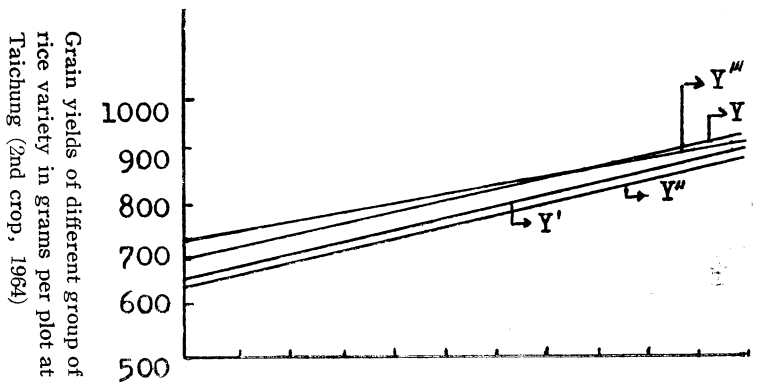
We may now proceed to discuss the results of second crop of the experiment which was also carried on at the 4 localities from north to south in the Province.

From the record of grain yields of 2nd rice crop 1964 in Taipei (Fig. 5, page 6), we found that when 4 variety groups cultivated together in Taipei, the Pintung group was the highest yielder. And the growing duration from sowing to heading was also the longest. This further noted that the Chiayi varieties rank next, the Taichung varieties, the third, and the Taipei varieties the shortest in the number of days of growing duration. The weight of grain yield is positively propertional to the number of days of growing durations.

Under Taipei weather condition, if hybrid progenies are too late in maturity in the 2nd crop, they are always discarded either by natural or by artificial selection. However, though the rice varieties developed from Pintung and Chiayi are among the highest yielders, but they were always mixed with many green grains. Due to colder weather in late Fall in Taipei, so we may say that only the Taichung varieties yielded plump seeds are better than Taipei varieties in the 2nd crop in Taipei region.

If the varieties from Pintung and Chiayi were cultivated in Taipei during the the 2nd crop period, they do not happen to meet the early-coming cold weather in Oct. & Nov., then they would able to give a better harvest in Taipei than Taipei local bred varieties. So it indicats that the varieties developed from southern part of this province may have the posibility to adapt to the regions north-ward of Pintung or Chiayi. However, it may be certain that only the Taichung varieties may give better repening grains during the second crop period in Taipei.

$Y = 696.20 + 22.83\,x$ (Taipei varieties)
$Y' = 655.44 + 23.95\,x$ (Taichung varieties)
$Y'' = 641.21 + 22.79\,x$ (Chiayi varieties)
$Y''' = 726.76 + 18.42\,x$ (Pintung varieties)



Each scale represents the position of each variety (pure line) arranged by order of yielding ability.

Fig. 6: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Taichung (2nd crop, 1964)

In Taichung (see Fig 6), the second rice crop of 1964 in the experiment was suffered from Sclerotium diseases. In addition to the soil condition of the experimental field which was too rich, most of the varieties in the experiment were not prevented from lodging. But the Taipei and the Pintung varieties were not so serious when they compared with Taichung and Chiayi varieties.

During the breeding programs were taken place in Taipei and Pintung, both regions were under the circumstances of being more easily attacked by the Sclerotium pathogen, and hence most individuals which were not resistant to Sclerotium diseases were discared in early generations. In addition to the artificial selection, the varieties developed from Pintung and Taipei are more resistant to Sclerotium disease than the Taichung and the Chiayi varieties.

All varieties developed from the 4 localities yield steadily in Taichung, and the range of grain yield of the varieties from minimum to maximum is rather narrow than the other 3 experimental places.

Comparing the yielding capacity of four rice variety groups in Taichung, we find that Taichung is the highest yielding place of rice crop than the other 3 experimental localities in the second rice crop.

It seemed to be that Taichung is the best place for growing many rice varieties from different places during the 2nd crop. But if one want to extend a good variety in Taichung successfully for the second crop it should be able to resistant to Sclerotium diseases and to with-stand from lodging.

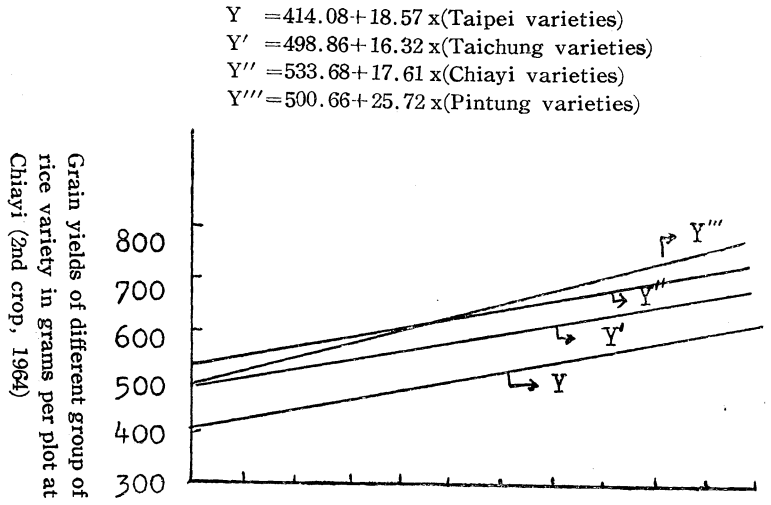


Fig. 7: Trend lines of yielding capacity of 4 rice variety groups bred at different localities cultivated in Chiayi (2nd crop, 1964)

In Chiayi(see Fig 7),during the second crop of 1964, all rice varieties in this experiment were attacked by a new virus which occured only in recent years and originated from Pintung. Varieties developed from Chiayi and Pintung are comparatively

resistant to this sort of disease, whereas varieties from Taichung & Taipei are most susceptible to it. So the yielding capacity of Pintung and Chiayi varieties are rather higher than those of Taichung and Taipei varieties. This fact was discovered in a former research work by the present author that some Ponlai varieties (Japonica) developed from Pintung & Chiayi are very resistant to the new virus disease.

So far as we know, the following varieties; (1) Chianan 2, (2) Kao-yu 10 (3) Kaohsiung 68 and (4) Kaohsiung 122 are all the most resistant varieties developed from the southern Taiwan. [The number (1), was bred from Chiayi, & the (2) (3) & (4) from Pintung.]

The Taichung and the Taipei rice varieties were susceptible to the new virus disease, and some of the varieties, suffered very seriously to such a extent that they near to extinguish.

The relavent experiment was also carried out in Pintung during the 2nd crop of 1964. The results are abnormal due to poor drainage of the experimental field. So the data are not availiable for comparative studies.

CONCLUSION

According to the experimental results are shown above, Taichung & Chiayi should be the better sites for rice breeding work in Taiwan, The varieties developed from there possessed more extansive adaptability than Taipei & Pintung varieties.

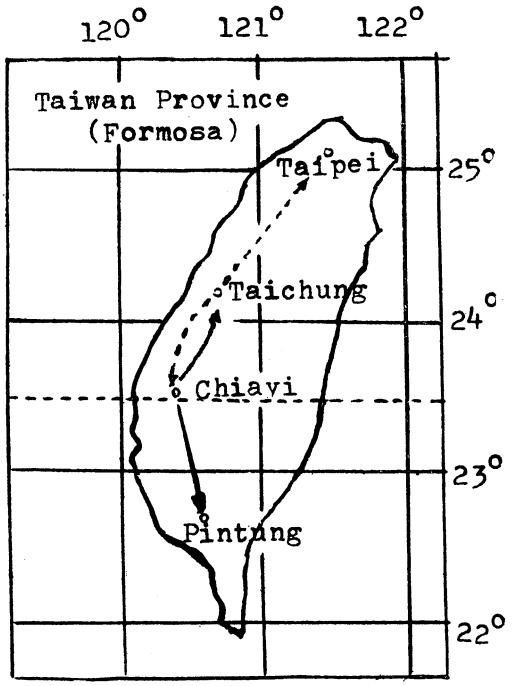
Varieties developed from Taipei and Pintung excepting in a few cases are always with narrower adaptation. Not only during 1st crop but also in the 2nd crop of rice as well, the southern varieties may adapt the regions northward, but conversely, the northern varieties have very little possibility of adapting the region southward. Temperature and photoperiodism condition may not be the only cause, but there must have existed some characters of the varieties which may resist to pest and insect damages of the southern varieties. Pest & insect damage are more serious in southern part, than in the north, when a pureline is selected from the hybrid population in the southern area, it is always quite resistant to many sorts disease and insects. Lines retained after natural and artificial selection in the south were possessing characters with tolerated to the adverse environment more than the northern varieties.

In the first crop, varieties developed from Taichung were adapted well northward to Taipei, and southward until reached Chiayi. But in the 2nd crop, these varieties are not so tolerate to some new sorts of disease which occured in the southern part, even in Chiayi. Taichung varieties did not have good performance in the 2nd crop in south because of new virus disease infection. However, Taichung is neverthless a good place for rice breeding in Taiwan. Because the varieties developed from the region may adapt to both the northern and the central regions of Taiwan. Yet in the futere, rice breeding in Taichung should use artifitial inoculation with all important discases in order to select more resistant lines.

Chiayi varietes yielded higher in Pintung in the 1st crop, whereas Pintung varieties were not so adaptable to Chiayi. So it seems to be that Pintung is only

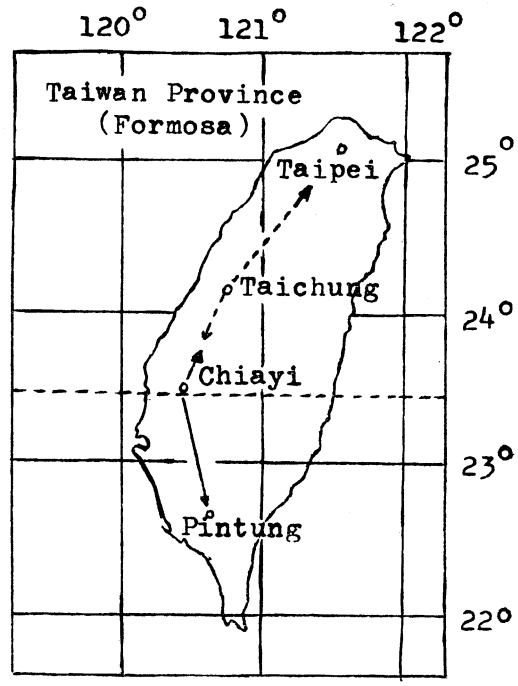
the place for breeding local rice varieties. Apparently, Chiayi is an ideal place for breeding rice varieties for the southern Taiwan. In addition to its varieties having broad adaptation in southern area it has also the benefit of good natural environment in which rice blast disease prevail. It is in this connection that the Chiayi Agricultural Experiment Station has its increasing importance in the rice breeding task of this Province. Taipei or Pintung may carry on rice breeding work for their own special purpose, the development of new lines resistant to the local disease, as well as some foundamental researches on rice crop which would be strengthened in the future.

After this study, a conception of two efficient centers (Taichung and Chiayi) for rice breeding in this province was found, and the adaptation of their variety groups are shown as the following figures:



----→Most Suitable Extension Direction of the Taichung Rice Varieties (1st Crop)
——→Most Suitable Extension Direction of the Chiayi Rice Varieties (1st Crop)

Fig. 8: Extension Directions Available for the Rice Variety Groups Bred in Taichung and Chiayi Respectively During First Crop.



----→Most Suitable Extension Direction of the Taichung Rice Varieties (2nd Crop)
——→Most Suitable Extension Direction of the Chiayi Rice Varieties (2nd Crop)

Fig. 9: Extension Directions Available for the Rice Variety Groups Bred in Taichung and Chiayi Respectively During Second Crop.

REFERENCES

(1) Chen, C. C., Chien, C. C. & Hwang, T. T. (1961): Studies on the Sclerotial Disease of Rice Plant in Taiwan. Jour. of Taiwan Agri. Resear. Inst. Vol X, No. 2.

(2) Chang, S. C., Tseng H. D. & Pun, Y. S. (1948): A Discussion on the Experimental Results of the Optimum Fertilizer Ratio for Rice in Taiwan. Bulletion 7 of T. A. R. I.

(3) Chiu, R. J., Lo, T. C., Pi, C. L. & Chen, M. H. (1965): Transitory Yellowing of Rice and Its Transmission by the Leafhopper *Nephotettix apicalis apicalis* (Motsch.) Botanical Bulletin of Academia Sinica Vol VI No. 1.
(4) Lo, T. C., & Hsieh, S. P. Y., (1964): Studies on the Stem Rot of Rice Plant 1. Distribution & Economic Significance of the Disease. Plant protection Bulletin Vol. VI. No. 3.
(5) Miu, T. S. & others (1959): A Photographic Monograph of the Rice Varieties of Taiwan. Special Publication II of T. A. R. I.
(6) Miu, T. S. (1964): A General Review of Rice Breeding Work in Taiwan.
(7) Miu, T. S. (1964): The Theoretical and Practical Aspects of Using Resistant Variety of Rice to Repress Brownwilt Disease of Paddy in Pintung. Jour. of Taiwan Agri. Resear. Inst. Vol. XIII, No. 4.
(8) Taiwan Agri. Resear. Inst. (1961): Symposium of Studies on the Causes or Low Yield of Rice in Tropical and Sub-tropical Regions.

不同環境因子對稻雜交育種後代集團遺傳形質選擇之影響

第一報　各地育成新品系羣產量趨勢線之差別

繆　進　三

摘　要

作者舉行兩個稻品種雜交組合，㈠嘉農242×Baritol，㈡臺中65×Baritol，母本「嘉農242」及「臺中65」，均爲目前本省適應性較强之水稻品種。父本則爲山地陸稻；希望由此育成抗病及耐旱品種，並同時研究相同遺傳質之雜交後代集團，在連續世代中，因在不同緯度環境下分離組合，由於自然因子之淘汰作用，在育種過程中，所加於品系入選機會之影響，有何差異，以供研究本省稻作育種，自然分區之論據。

48年（1959）夏，種植上述兩組合之 F_1 種子，各 20 粒，乃得充分之 F_2 種子；此項 F_2 種子充分拌和後，於49年春，平均分配於臺北、臺中、嘉義、屏東等四處地方，每地每組合各種植2,000株，如此就收穫之 F_3 及其連續後代種子，逐年抽取 $1/10$，爲次代種植之用。每年分春、秋兩季各種植一期，直至第6代起，選擇單株，分區建立純系；再經各地歷年穗行試驗及品系比較試驗，作產量比較，及抽穗期比較，（選擇比對照種臺中65號產量稍高或相等，且其抽穗期相差 1-2 天以內者），予以淘汰選擇，每處各選出12品系，四處合計48品系，舉行綜合性之區域適應試驗，試驗地點仍分在原來之四處育種地點。每處12品系，包括來自第㈠及第㈡組合者各 6 品系，其代號如下：

育成地 \ 組合	嘉農242×Baritol	臺中65×Baritol
臺北品系	北 北 北 北 北 北 ① ② ③ ④ ⑤ ⑥	北 北 北 北 北 北 ⑦ ⑧ ⑨ ⑩ ⑪ ⑫
臺中品系	中 中 中 中 中 中 ① ② ③ ④ ⑤ ⑥	中 中 中 中 中 中 ⑦ ⑧ ⑨ ⑩ ⑪ ⑫
嘉義品系	嘉 嘉 嘉 嘉 嘉 嘉 ① ② ③ ④ ⑤ ⑥	嘉 嘉 嘉 嘉 嘉 嘉 ⑦ ⑧ ⑨ ⑩ ⑪ ⑫
屏東品系	屏 屏 屏 屏 屏 屏 ① ② ③ ④ ⑤ ⑥	屏 屏 屏 屏 屏 屏 ⑦ ⑧ ⑨ ⑩ ⑪ ⑫

以上各品系分在臺北、臺中、嘉義及屏東四處地方種植，53年第一期作三行區每行10株（7×8寸）重複二次，53年第二期作則重複六次。本田在幼苗活着後，一律採取每隔5日之節水輪流灌溉，其他一切肥培管理，均照當地例行習慣，成熟期收穫種穀，配合產量趨勢線，以資互相比較。

根據本研究結果，在臺灣，稻作育種，以在臺中及嘉義二地效率最佳。臺北及屏東育成品系，除少數特殊情形外，適應範圍均較狹。再則無論第一期作或第二期作，南部品系尙可向北適應；臺北品系，甚少有向南能適應者。除由於光照溫度之感應關係外（溫度影響尤大），南部天氣溫暖，病蟲害種類較多，而病況常較重。在該種情形下磨煉淘汰後，所有南部育成品種對病蟲害抵抗力均較强。臺中育成品系無論第一期作或第二期作，向臺北或嘉義均尙有相當適應力，但就第一期作已有之資料表示，並不適應於屏東；又第二期作如在嘉義遭遇新毒素病時亦減產。嘉義育成品系，向南可適應於屏東。向北常因遲熟而效果欠佳。屏東地區除栽培其本身育成之品系外，以種植嘉義育成品系爲佳。

根據本試驗研究所得數據，予以統計分析及推理研究，臺中、嘉義二地，臺中居全省中央；嘉義位於北廻歸線上，且有適宜之天然接種稻熱病及螟蟲環境，育成品系適應性均較强，應爲本省稻作實用性育種之兩大自然中心。但仍應加强育種過程中之人工接種病蟲害設備及措施。屏東及臺北，僅可能育成地方性品種適應局部特殊環境之需要；並適宜作育種理論性問題之基本研究。第二期作缺少屏東區數據，正繼續試驗中。